

Modeling within a digital watershed context

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Digital watersheds offer a rich spatial environment for supporting hydrologic science and water resources management. They can be used to manage and integrate data from diverse sources, to visualize hydrologic events, and to convey information to stakeholders. Another benefit of digital watersheds is in supplying a consistent digital representation that benefits hydrologic modeling. Existing models can make use of a digital watershed as a spatiotemporal database for parameterization, setting of boundary and initial conditions, and calibration. New models stand to benefit even more from the digital watershed concept because they can be written specifically to interface the digital watershed and to supplement the observed data by filling in gaps and forecasting future events.

The idea of digital watersheds is relatively new and different proposals have been put forth for the design of digital watersheds. Maidment (2002) presents a geospatial data model named Arc Hydro for digitally representing a river basin system that can be used as a common data framework for supporting model implementation (Whiteaker et al. 2006a) and integration (Knebl, M. R., et al., 2005; Whiteaker et al. 2006b). Goodall and Maidment (forthcoming) suggest a set of generic spatiotemporal data types designed specifically for hydrologic modeling (flux, control volume, and flux coupler) as the fundamental building blocks for creating a digital watershed. Finally, Moore and Tindall (2005) and Gregersen et al. (2007) offer the concept of standardizing the exchange items passed between coupled models and the interface between the model so that they can be coupled within a digital watershed context. This concept has been implemented as the Open Modeling Interface (OpenMI) standard.

While OpenMI was originally developed to couple existing commercial hydrologic models, it could also be used as the fundamental idea for building models within a digital watershed. In this case, a model exists as part of the overall watershed system, gaining its initial conditions and state variables from the digital watershed. At the same time, the model is able to derive boundary conditions as it progresses through time either from the digital watershed or from other models that are implemented within the digital watershed. If boundary conditions are obtained from other models within the digital watershed (e.g. a groundwater model obtaining infiltration values from a surface hydrology model), it is possible to have feedback loops between the two models so that the two models are fully coupled and feedbacks can be accounted for.

There are many benefits to this interface-based technique for creating models within a digital watershed. Because only the interchange between models and not the internals of the models themselves are standardized, it is possible for each model to have its own internal data models, semantics, scales of operation, and process representations (e.g. numeric, empirical, statistical, etc.). This greatly benefits interdisciplinary modeling where not all system processes can be described on the same space-time scale or with a partial differential equation. Perhaps

the most valuable attribute of the interface approach, however, is that it distributes the task of model development, maintenance, and even execution across organizations. As long as each organization adheres to the established interface standard, their model will be able to work within the digital watershed. Furthermore, models could be physically located on different computers and interconnected through web services, opening the door to cyber-based modeling within a Service Oriented Architecture (Goodall and Castronova, 2008).

We have explored using interface standardization specifically for constructing process-level models that would operate within a digital watershed. Our approach builds from OpenMI and offers a simplified interface standard that allows for quick implementation of new models as OpenMI-compliant models. In this talk, I will demonstrate our approach through a simple modeling example that uses two models, a rainfall abstraction component and a stream routing component, to simulate watershed response. Each model consists of two parts: (1) an XML-based configuration file that defines the model metadata, initial conditions, and input and output exchange items (i.e. the boundary conditions) and (2) a library (DLL) that implements our ISimpleModelWrapper interface. This simplified interface consists of only three methods (Initialize, PerformTimeStep, and Finalize), but is still OpenMI-compliant. As with any OpenMI-compliant model, all time iteration is handled external to the model by a controller application that facilitates the transfer of data between interlinked models.

We have built two prototype models using this approach, a rainfall abstract component and a routing component that can be coupled to simulate overland flow. I will demonstrate how the components are built, as well as how they can be used to simulate a watershed system. The demonstration will highlight the role of the digital watershed in the modeling system and show how interface standardization allows for a scalable solution to modeling within a digital watershed. Each model can be interchanged with another model that has the same input and output exchange items. Also, each model can be further developed by independent teams yet still work within the overall modeling system. Finally, I will present an outline for future work on how to enhance interface-based modeling within a digital watershed context.

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